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ABSTRACT

A series of case studies were undertaken by UNESCO to probe more deeply into the adequacy of science, mathematics, and technology curricula to meet national needs, and their appropriateness in relation to the rapidly-evolving nature of science and technology themselves. This fifth study, from Pakistan, has focused on the following 4 major areas: (1) the place of science, mathematics, and technology in the curricula of primary and secondary schools; (2) the content of the curricula in science, mathematics, and technology and the ground covered in each subject at the end of primary education, and at the end of secondary education; (3) the content of courses in integrated science which are offered to students in secondary schools, as well as a summary of the content of the separate science courses; and (4) the policy of the Ministry of Education on the place of technology education in primary and secondary schools, the resources implied by the policy and efforts that are currently being made to implement it. (PR)

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Science and Technology in School Curricula

Case Study 5
Pakistan

Unesco

Division of Science
Technical and Environmental
Education

ED-89/WS/5

Paris, 1989

Preface

In 1986, Unesco published a global survey on the place occupied by the teaching of science, mathematics and technology in school timetables[1]. To probe more deeply into the adequacy of science, mathematics and technology curricula to meet national needs, and their appropriateness in relation to the rapidly-evolving nature of science and technology themselves, a series of case studies were undertaken.

This fifth study, from Pakistan, has focussed on the following four major areas:

i) the place of science, mathematics and technology in the curricula of primary and secondary schools;
ii) content of the curricula in science, mathematics and technology and the ground covered in each subject at the end of primary education, and at the end of secondary education separately;
iii) content of courses in integrated science which are offered to students in secondary schools, as well as a summary of the content of the separate science courses;
iv) policy of the Ministry of Education on the place of technology education in primary and secondary schools, the resources implied by the policy and the efforts that are currently being made to implement it.

The school education in Pakistan is distinctly divided into four levels, namely Primary, Middle, Secondary and Higher Secondary. The number of years of schooling for these levels are 5, 3, 2 and 2 respectively. The age of entry to Grade I at the Primary level is 5+. Diversification for professional/vocational education mainly takes place after the Secondary and Higher Secondary levels. The scope of the present study has been restricted only up to secondary level.

The material for the report was collected through questionnaires, direct interviews, Government publications/reports, visits to educational institutions, etc.

A National Team consisting of the following was constituted to undertake the work:

- Mr. Abdullah Khadim Hussain,
  JEA (C.W.)
- Dr. Ijaz Admad Chaudhry,
  DEA, Ministry of Education
- Mr. Muhammad Ibrahim Khan,
  DEA, Ministry of Education
- Dr. R. A. Siyal,
  AEA (Chemistry)

Mr. Abdul Rased and Mr. Aurangzeb Rehman, Assistant Educational Advisers in the Ministry of Education, also contributed to the work.

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1. *The Place of Science and Technology in School Curricula: A Global Survey*. Unesco 1986.

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THE SETTING

The Islamic Republic of Pakistan came into being on 14th August, 1947. It lies between the 23.4 and the 36.5 parallels of northern latitude and the 60.4 and 75.2 degrees of eastern longitude. Its total area of 796,095 sq. km. comprises Federal territory and four provinces, namely Punjab, Sind, North West Frontier Province (NWFP) and Baluchistan. Its present population is about one hundred million, with an annual growth rate of 2.9 per cent. The population is unevenly distributed among the various provinces. Punjab with 56.1 per cent of the whole has the biggest population, while Baluchistan, the biggest in area, has only about 5.1 per cent of the population.

About 70 per cent of the population live in rural areas. These are characterized by poverty, mass illiteracy, small land holdings, under-utilized farm labour and low yields.

EDUCATIONAL PROVISION

In the formal system, a three-tier system of education is presently in operation, comprising a primary, a middle and a secondary stage. The primary stage includes Grades I to V, the middle, Grades VI to VIII and the secondary, Grades IX and X.

Particular schools may provide more than one educational stage. Primary schools cater for only grades I-V. Middle schools may include Grades I-VIII or only Grades VI-VIII. Secondary schools may similarly include Grades I-X or Grades VI-X or only grades IX-X.

The school year is made up of 35 working weeks, each of 5½ days. In classes I-III, a working week includes 30 periods. In classes IV and V the week is raised to 40 periods, while in middle and secondary classes 45 periods are prescribed. All 'periods' are of 40 minutes duration.

In classes I-III, the curriculum emphasises language, with more than one-half of the time being devoted to speaking, reading and writing in the child's first language. In IV and V, a second language is added, science is introduced and manual work begins. At the middle level, two more languages are prescribed, namely English and Arabic, while choice is offered as between Islamic studies and moral education and also either art or Persian language or agriculture may be chosen. Finally, at the secondary level, diversification takes place and students opt to enter either the Science group or the General group. Eight subjects are taken. Those of the Science group are Urdu, English, Pakistan studies, Islamiyat, mathematics, physics, chemistry and biology. The general group, however, take general science and two vocational subjects chosen from a wide list.

THE PLACE OF SCIENCE, MATHEMATICS AND TECHNOLOGY

Science

Science is taught as a compulsory subject in all three levels. In Grades I and II, the treatment is oral with some activity. The regular teaching, however, starts in Grade III and a separate book is prescribed. Great care is taken in selecting and providing appropriate experiences so that the child is led systematically to an understanding of the basic concepts.

Science in the middle level is integrated and boundaries between physics, chemistry, biology, astronomy, etc. have been done away with. The subject matter is, however, divided into three broad areas of content: living things, matter and energy, and earth and universe. This division does not involve any rigid grouping of concepts. Rather, the concepts in all the three areas overlap and are reinforced through a spiral approach at different levels of maturity. The three broad areas of content have been broken down into basic concepts which the children can grasp at their particular stage of development. Activities are also suggested to help the children to understand the concepts through direct experience of them. These experiences are of all kinds. They include the children's own activities and discoveries, as well as the teacher's demonstrations and verbal instructions. The use of pictures, charts, newspapers and improvised equipment, is also suggested.

Two types of science courses are offered at the secondary level (Classes IX-X). Students in the general group study integrated science. This is a continuation of the middle level course. The course is derived from topics from chemistry, physics, biology, astronomy, etc. in an integrated structure. It is purely theoretical. The students do not perform any practicals although the teachers may arrange some demonstrations to

explain various concepts. Students in the science group study chemistry, physics and biology as separate disciplines. The courses are of an academic nature and practical exercises form a part of the curricula.

Mathematics

Mathematics is a compulsory subject at all levels. At the primary level, the conventional four rules for working with numbers are taught together with simple geometric exercises. At the middle level, students study arithmetic, algebra and geometry. The course includes some understanding of modern mathematical concepts, enabling the child to solve problems which have a practical value in the real world. At the secondary level, the courses for the science group and for the general group are different. They are named 'elective mathematics' and 'general mathematics' respectively. The course in elective mathematics (for the science group) provides those skills in algebra, trigonometry and geometry as will prepare the students to solve problems in scientific and technical fields. The course of general mathematics (for the general group) includes topics drawn from arithmetic, algebra and geometry.

Technology

The inclusion of productive work in general education formally starts at the middle level. A package of five subjects is available and students may choose one of electricity, woodwork, metalwork, agriculture or home economics. The latter may be chosen only by girls. Agriculture is taught in rural schools. Urban schools provide instruction in industrial arts.

At the secondary level, a number of technical and vocational subject are included in the scheme of studies for students of the general group. The students can choose any one of them. No technical or vocational subject is offered to students in the science group.

THE OBJECTIVES AND CONTENTS OF THE SCIENCE AND MATHEMATICS COURSES IN THE ELEMENTARY AND MIDDLE STAGES.

Science

Science at the *elementary stage* is taught as an integrated course, reflecting the essential unity of science to children, who, in real life, perceive their environment as a whole. It aims at helping children to absorb concepts of science through the discovery method and to bring them to a deeper appreciation and understanding of their environment. The ultimate goal is to bring the pupil to a stage where he or she takes delight in being involved in learning science and feels committed to continue its study.

The content of the teaching in the primary classes revolves around three broad areas: living things, matter and energy, and the earth and the universe.

As to *living things*, their diversity and similarity in terms of size, shape, movement, etc. is followed by their general characteristic features. The differentiation between living and non-living things is systematically explored, as is the effect of living things on the environment. Elementary ideas about reproduction and growth are given, using happenings and occurrences within the child's experience.

The subject of *matter and energy* is developed around materials in the child's environment. Elementary notions about three states of matter are imparted, as, too, are the concepts of force, heat, light, friction, the process of burning, magnets, levers, machines, electricity, sound, and atmosphere. Water and contamination are systematically developed.

The *Earth*, the sun, the moon and the stars are presented as spherical bodies, and the attempt is made to point out the salient features that characterize them, The rotation of earth, and the causes of day and night and of the various seasons is explained.

The content of science teaching at the *middle level* has been developed as a continuation and an extension of the content developed for the elementary stage. Thus, in each of the classes VI, VII and VIII, the work falls broadly under the headings of living things, matter and energy and the earth and the universe. Topics, however, are more detailed. Thus, *living things* include concepts of habitat and environment, of classification, micro-organisms, the structure of plants and animals, food and nutrition, cellular structure and reproduction. Similarly, *matter and energy* now includes the effects of heat, atmospheric pressure, the reflection and refraction of light, electro-statics, current electricity, magnets, machines, the atom, the elements, mixtures and compounds, acids and bases, etc. Likewise studies of the *earth and universe* deal with

the interior of the earth, the sun, the moon, the solar system, satellites (both natural and artificial), comets, meteors, stars and galaxies.

Mathematics

During the *elementary stage* (Grades I to V), the teaching is geared to imparting pre-number concepts, the real numbers and computation in the four fundamental operations. Money and the calendar are taught. So is the reading of bar and line graphs. Other topics include measurement, unitary method, average, the concepts of angle, right angle, right triangle and quadrilateral. Also the area and perimeter of triangles, and quadrilaterals, the concepts of a cube, a cuboid, of volume and its measurement.

In *middle level* classes, arithmetic continues with H.C.F., L.C.M., fractions, ratio and proportions, averages, percentages, real numbers, and graphs, particularly the concept of bar graph and line graphs. Algebraic operations are also taught, so is the concept of directed numbers.

In geometry, the work includes line, angle, quadrilateral, triangles and their areas and perimeters, cube, cuboid and the calculation of its volume, the cone, its surface area and its volume. Pythagoras' theorem and its applications are taught, though proof of the theorem is omitted.

SCIENCE AND MATHEMATICS IN SECONDARY CLASSES

As mentioned earlier, the single stream followed up to Class VIII divides in Classes IX and X. A choice of two streams is offered. In one, the general stream, students are offered courses in integrated science and general mathematics, while in the science stream, students take three science subjects, physics, chemistry and biology together with a full course in mathematics. In what follows we discuss, first, the work of the general stream and then the more specialized courses followed by the science stream.

Integrated science

In order to continue the development of scientific literacy among the children and also to foster a scientific attitude towards the solution of everyday problems, integrated science (or general science) is taught to non-science students. The work has been developed as a continuation and extension of the course followed from Class I to Class VIII. Since Classes IX and X terminate science education for the non-science group, the attempt is made to bring to the notice of the young school leavers some understanding of the methods, processes, applications and the social and other implications of science in the modern world.

The content of the two-year course is built on the foundations of ten major themes: the history of science, science and society, the cellular basis of life, micro-organisms, the human body, the necessities for human life, inside the atom, modern technology, energy and natural resources.

A brief introduction to the *history of science* aims, first, to explain the nature of science and to relate its study to the Islamic injunctions on the acquisition of knowledge. The processes of science are explained, namely observation, experimentation, measuring, comparing, using instruments, the interpretation of data, the formulation of hypothesis and the development of theory.

The various branches of science are briefly explained: astronomy, biology, chemistry, geology, physics, etc. At the same time, the unity and the interdisciplinarity of science are emphasized. Finally, developments of modern sciences are discussed with particular reference to the contribution of Muslim scientists.

In the context of *science and society*, the role of technology, defined as the application of the findings of science, is brought out and some important technologies in the fields of agriculture, medicine, pharmacy, engineering are used to illustrate how science forms part of human culture. This leads naturally towards the effects of science on economics, politics, demography and on social structures.

Discussion of the *cellular basis of life* permits an introduction to chromosomes and genes, as well as speculation about the origin of life.

Under the heading of *micro-organisms* are discussed bacteria and viruses, harmful and useful organisms, and diseases caused by micro organisms. Protection and preventive measures are emphasized as well as the importance of immunization against diseases caused by bacteria and viruses. The nature of a cancerous cell is also explained as well as the disease itself.

The functioning of the *human body* offers a focus for the role of food, and the major constituents of food. The body's need for energy provides a context for fats, carbohydrates, proteins, etc. Vitamins and minerals and their role in the body are also discussed.

The need for a balanced diet for all, but especially for infants and lactating mothers, permits examination of what is meant by a balanced diet. This phase of the work concludes with the process of aging, bodily decay and ultimate death.

The *necessities for human life* provides scope for discussing the occurrence of carbon in nature and its allotropic forms. Likewise, the air we breathe brings out the importance of oxygen as supporter of life and of nitrogen as a constituent of fertilizers. The nitrogen cycle can then be introduced. Sources of air pollution raise the question of how to keep air clean.

Reverting to the human body, attention is drawn to the importance of calcium, magnesium, sodium, iodine, chlorine, phosphorus, sulphur, iron and other trace elements for maintenace of good health, as well as the effects of a deficiency of iodine and of other elements in the human body.

Inside the atom provides insights into atomic structure, the different elements and their isotopes in nature. Discussion follows of stable and unstable atoms, radio-active elements, laboratory-made elements, and the use of radio-isotopes in agriculture, medicine and industry.

Atomic fission introduces the ideas of fission reaction, moderating neutrons, critical mass, chain reactions, controlled and uncontrolled reactions, sources of atomic energy, nuclear energy and safety.

Modern technology introduces such applications of science as the internal combustion engine, radio, electrical and electronic gadgets, computers, lasers, etc.

The topic also provides a context for discussing the exploration of space leading to new knowledge about heavenly bodies, better communications and weather forecasts as well as the preparation of chemical compounds and materials under conditions of weightlessness.

Pupils learn also about Pakistan's space programme, particularly the setting up of a receiving station and remote sensing equipment for receiving information from weather satellites, landsat, etc. and placing two geostationary satellites for our own use.

Energy opens with the nature of energy, and its forms, potential and kinetic, chemical energy in fats, coal, gas and petroleum, solar energy and its use e.g. the windmill, hydro-electric power, tidal energy, and nuclear energy.

Man's use of energy begins with energy consumption in homes and schools, the energy used in industry and in transportation.

Finally, energy is seen as a resource to be conserved as far as possible.

The course concludes with a wide-ranging examination of the *natural resources of Pakistan*, its minerals, (coal, gas, oil, chromium, gemstone, gypsum, mica), its major chemical industries (cement, steel, sugar, fertilizers), its agricultural produce (fruits and crops, dairy farming and dairy products), its wildlife and national parks, its marine and aquatic reserves.

Attention is particularly drawn to the water resources of Pakistan, its rivers, lakes, springs, dams, hydro-electric power, and the importance of conserving them. Other aspects of conservation relate to ecological balance, deforestation, the destruction of land, water-logging, salinity and urbanization.

General mathematics

The principle objectives of this course are to provide the average student with feeling of competence in solving the computational problems of daily life and to ensure a sound basis for higher education in social sciences. To this end, the content covers both traditional and modern topics in arithmetic and algebra, together with a few basic ideas of statistics, such as class-interval, frequency, mean, mode and median, computation with the help of logarithms, applications of ratio and proportion and such applications of percentage as civic taxes, discount, instalment purchases, loans from banks, societies and corporations, ordered pairs and Cartesian product, though the latter naturally extends to the traditional system of Cartesian coordinates.

The usual rules of algebra are taught, including the expansion of the squares and cubes of binomials and simple factors. The solutions of linear equations in two variables are illustrated graphically and this leads to the graphical solution of systems of linear equations in two variables and to problems which lead to such systems. Also, 2x2 matrices are discussed.

Geometry is taught informally, but the content of the work is traditional, covering, as it does, the congruence of triangles, the construction of triangles (including the ambiguous case), the theorem of Pythagoras and simple applications of it, similarity, and the tangent and angle properties of a circle.

Chemistry

Chemistry is one of the three components of science followed by the science stream at the secondary level. The main aim of teaching chemistry at this stage is to impart functional literacy in chemistry, so that the

students will appreciate the role of chemistry in shaping their environment, in society and in the nation. More broadly, the intention is to prepare students for professional careers in chemistry, to contribute to a general education using chemistry as a vehicle, and to inform future citizens of the nation about the role which chemistry plays in everyday life.

The content of the chemistry course is specified under some sixteen broad areas including the introduction which touches on the history of chemistry, its methods and branches, together with the units of measurement it employs and the devices it uses. The work then passes to the constitutents of matter: elements, compounds, mixtures, followed by valency, gram-atomic/molecular weights and the balance of a chemical equation.

Reactions are now considered, particularly simple decomposition, synthesis, hydrolysis, neutralization, displacement and double decomposition. Atomic structure follows with a discussion of various atomic models, the arrangement of electrons, and the consequent arrangement of elements in groups and in periods.

Chemical bonding leads on to solutions and thence to acids, bases and salts. Next to be considered is the dynamics of chemical reactions, including chemical equilibrium, unsaturated, saturated and super-saturated solutions.

Six elements are then studied for their social importance, namely hydrogen and water, carbon - its different forms and compounds - nitrogent and phosphorous for their importance as fertilizers, and oxygen and sulphur, including the alliotropic forms of sulphur, its compounds and their uses.

The halogens are then studied as a group as are the metals. There follows a brief history of organic chemistry, together with a look at some important organic compounds, their preparations, properties and uses.

The course concludes with some insights into the industrial world - the manufacture of soap, ghee, sugar, cement, paper, glue, polish, toothpaste, electroplating, the metallurgy of iron, etc.

Physics

Physics, too, is a component of the sciences which the science stream is required to take in Classes IX and X. The course is planned in twelve units, the first of which is a historical introduction, with special reference to Muslim contributions. A study of motion follows. This includes linear, rotatory and vibratory motion (and rest), displacement, speed and velocity (uniform, variable and average), acceleration together with the equations which relate distance, time, speed, and the uniform acceleration of bodies falling near to the surface of earth. The third unit teaches the concept of force, the laws of motion, inertia, mass and weight, and the measurement units of force. The course then passes to a discussion of scalars and vectors, followed by vector representation, vector addition, vector subtraction and the multiplication of a vector by a scalar. Other topics in this unit are the resolution of vectors, the moment of a force, torque, centre of gravity, equilibrium and its conditions.

The fifth unit contains a complex of ideas: gravity and its variation with altitude, the mass of the earth, circular motion, centripetal force, centrifugal force (as a force of reaction), energy and its various forms, the conservation of energy, work, power (and their units), input, output, mechanical advantage and the efficiency of a simple machine, the mechanical advantage of lever, movement on an inclined plane, the simple pulley, momentum and its conservation (descriptive).

Unit 6 begins with the molecular theory of matter, describing the distinctive features of three states. Then the Brownian movement, followed by the diffusion of liquids and gases. Next elasticity, stress and strain, Hook's law, Young's modulus, density, the pressure of liquids and gases, the manometer, Pascal's law and the hydraulic press. Finally, Archimede's principle and floating bodies.

Units 7 and 8 are concerned with electrical phenomena: positive and negative charges, Coulomb's law, electric field, electrostatic induction, electric potential, units of charge and potential, capacitance and its unit, fixed and variable capacitors. Then follows the idea of free electrons, current as a flow of charges, the units of current, Ohm's law, resistance, units of resistance, combinations of resistances, open and closed circuits, direct current and alternating current, the heating effect of current, Joule's law, electrical power and energy, magnetic field, magnetic needle, lines of force, the electromagnet, the electric bell, the galvanometer (moving coil type), ammeter and voltmeter.

Unit 9 includes a discussion of waves, some ideas about heat and an introduction to light. The first question, 'What are waves?' leads to harmonic motion and waves, longitudinal and transverse waves, characteristics of waves, wave length, frequency, time period, amplitude, the simple pendulum, waves and particles as carriers of energy, the production and propagation of sound waves, the velocity of sound waves, resonance, characteristics of sound, heat and temperature. Next follows the expansion of solids, linear expansion, coefficient of linear expansion, the expansion of liquids, including the apparent and real expansion of liquids. Then work and heat, units of heat, the law of heat exchange, specific heat, change of state, latent heat of fusion and vaporization, the effect of pressure on boiling and melting points, cooling produced

by evaporation, the refrigerator. The introduction to light starts with the laws of reflection, reflection from a plane mirror, spherical mirrors, the focal length of spherical mirrors, and the uses of spherical mirrors.

Units 10 and 11 continue the study of light with the refraction of light, the laws of refraction, refractive index, total internal reflection, refraction through prisms and lenses, images formed by a lens, the focal length of a lens, optical instruments including the camera, the eye and its defects, the simple microscope, the compound microscope and the astronomical refracting telescope. More theoretical considerations relate to the nature of light, the particle theory of light, photons, the wave theory of light, white light and monochromatic light, the dispersion of light, the spectrum made by a prism, the velocity of light, and the emission of light by an atom.

The concluding unit is designed to give an introduction to nuclear physics, natural radioactivity, the properties of Alpha, Beta and Gamma rays, half-life isotopes, radio-isotopes, nuclear fission, Einstein's mass-energy relation $E = mc^2$, nuclear fission, energy from the sun, the uses of atomic energy, radiation hazards and safety measures, electronics, semi-conductors, P and N type substances, semi-conductor diode and transistors.

Biology

Biology plays an important role in the education of the science stream partly because of its own importance, and also because it relates to the whole field of science itself. From the view point of education, one of the chief values of biology is that it brings together the methods and results of a number of other sciences. Biology draws on physics, chemistry and mathematics and acts as an integrating agent of study. Above all, biology helps us to understand ourselves and the world we live in. The great ideas of biology: evolution, ecosystems, and the chemical and physical bases of life have influenced all fields of human thought.

Biological findings, moreover, are of immense importance, for agriculture, forestry, fisheries and horticulture and these matter enormously in Pakistan since the bulk of the population live in rural areas and people are dependent on agriculture for livelihood.

Some fifteen units make up the two-year course. The first defines biology, explains Quoranic teachings about animals and plants and the contribution of Muslim biologists. It enumerates the major divisions of biology and their methods. The significance and relevance of biology to society are also explained. Study of the subject begins with the nature of life, Islamic concepts about the origin of life on earth, conditions on earth when life originated, biogenesis and abiogenesis, and Redi's experiments. It continues with the cell as unit of structure and function, tissues and tissue system, plant tissues, animal tissues, the structure of single-celled organisms, and the structure of multicellular organisms.

The fourth unit discusses diversity: the need for classification, units of classification, naming organisms, major groups of plants and animals with their diagnostic characteristics and familiar examples. Next come food and energy: nutritional requirements and different types of food, carbohydrates, fats, proteins, minerals, vitamins, the importance of water and of enzymes, nutrition in green plants, nutrition in animals, acquisition of food, digestion and assimilation of food, and the elimination of solid wastes.

Unit 6 is concerned with transport: diffusion, osmosis and active transport as basic mechanisms of conduction, transport in plants, transport in animals. This is followed by the process of respiration, involving the oxidation of food substances and the release of energy in green plants and animals: then the significance of excretion for excess of salts, water, and nitrogenous wastes, excretion in animals, and excretion in plants.

Unit 9 deals with coordination in multicellular organisms. This involves the concept of relationships with the external environment and responses to stimuli in plants, the introduction and significance of movements in plants, various types of plant movements, animals, sense organs, nervous communications, the brain and spinal cord as central components, nerves from sense organs and to affector organs, neuron and reflex, chemical communications, the concept of hormones and endocrine glands, the pituitary and organs it regulates, the thyroid, adrenal, pancreas, parathyroid, gonads, hormone imbalance and diseases, and locomotion in animals.

Unit 10 is concerned with reproduction, development and growth. This deals with types of reproduction, asexual and sexual, reproduction in plants, vegetative reproduction, budding, seed formation without sexual fusion, growth and reproduction in animals.

The work then moves to environmental considerations: population and community, human population growth, the distribution of organisms, establishment in a habitat, and extreme environments. The interdependence of living organisms is then discussed: animals depend upon plants, carnivores and herbivores, food chains and food webs, decomposers, the food cycle, ecosystems and how the balance between animals and plants is maintained. Finally parasites and symbiosis are examined.

Genetics occupies the twelfth unit. Variations within plant and animal species are examined, as are Mendelian laws of inheritance, alleles, genotype, phenotype, dominance and recessiveness, sex chromosomes

and sex determination, and the concept of genes. Finally hereditary diseases in humans are considered, e.g. haemophilia, colour blindness, and sickle cell anaemia.

Evolution occupies the last unit but one and the course concludes with the place of biology in human welfare: first in the broad sense of biology in relation to agriculture and forestry, honey bees, silk worm and lac insect, dairy products and meat, poultry, fish (and the importance of marine life), fuel, furniture and building material, diseases of plants, causes and remedies with reference to wheat, rice, sugar-cane and cotton, and insect pests and their control; second in the personal sense: biology in relation to health and nutrition, plant foods, fibre, medicines, useful aspects of bacteria, bacteria and food preservation, diseases due to to malnutrition, bacteria, viruses, fungi and parasite diseases. And, lastly, biology and the conservation of the environments: the pollution of air and water, soil erosion, causes and preventive measures, conservation of wild life.

Mathematics

The course for students in the science stream seeks to enable them to acquire an understanding of the concepts of mathematics and to apply them to the world they live in. It is also designed to provide students with a sound basis for specializing in mathematics in higher education and to apply it in scientific and technical fields. Other objectives are to develop the ability to distinguish between relevant and irrelevant data, to enable the students to draw correct conclusions from given hypotheses and to inculcate the habit of examining situations critically and analytically. Other aims are to awaken the students to the power of mathematics in generalization and abstraction and to foster in them the spirit of exploration and discovery.

The content of the course can be set out succinctly as, sets and numbers, exponents and radicals, algebraic sentences and matrices, quadratic equations, eliminations, variations, logarithms, trigonometry, vectors in a plane, deductive geometry and practical geometry.

TECHNOLOGY EDUCATION

Technical education in Pakistan is provided both in general education and in such specialized institutions as polytechnics established for the purpose. The emphasis in the special institutions is more on skill development than on education and a separate Directorate of Technical Education has been established to manage the polytechnics and the vocational and commercial institutions.

Here we discuss only the vocational element in general education.

Agro-tech education

As was mentioned earlier, a 'package' consisting of five subjects has been introduced into the scheme of studies at the middle level (Classes VI to VIII). The subjects are woodwork, metal work, electricity, agriculture, and home economics.

The 'package' is called 'Agro-tech Education'. Students may choose any one of them. Industrial trades (woodwork, metal work and agriculture) are for urban schools. Rural schools give instruction in agriculture. Home economics is taught only to girls. The principle of 'learning by doing' characterizes the teaching in these subjects.

In order to be purposeful, Agro-tech Education must be governed by specific aims. The aims should be all inclusive in that they embrace the three knowledge/learning domains, namely the cognitive, the affective and the motorsensor domains. In clarifying the aims, it is important to ensure that the potential of the individual child is developed so as to maximize his or her contribution to his or her future roles as an individual, as one of a family and as a member of the community. Some thirteen specific aims have been spelled out with these goals in mind.

In *agriculture*, the activities of Class VI revolve mainly around the study of soil, plants, vegetables, flowers and the elimination of weeds from the fields. The students learn the properties of a good seed, the necessary conditions for growth and the choice of a fertilizer. They learn about natural and artificial environments and the effect of these on the growth of plants. They study different types of soil, their properties and their effect on the growth of plants. The rearing of useful birds/animals is also taught and how to save them from intense weather.

The practical work includes the selection of seed, the preparation of the field for seeding and planting, the elimination of weeds, and a study of the soil around school and home.

Project work is undertaken in Class VII, and this involves the rearing of animals and birds, and growing plants and vegetables.

The theoretical work covers the different parts of a plants, the explanation of sign and root stock, painting, grafting, tubers, and the suckers of plants. Further study is made of vegetables in daily life, the selection of good seed, the preparation of the soil for seeding, different ways of seeding vegetables, and the proper use of fertilizer. An introduction is made to bee keeping, to rearing silk worms, poultry and birds, and rabbits, and the preparation of squashes.

Practical work includes the preparation of ground for the cultivation of vegetables and flowers, the rearing of silk worms, bees, poultry, birds, rabbits and the preparation of squash.

Metal work starts from very simple tasks and ends with difficult ones. The skills involved also evolve from simple ones to complicated ones. Most jobs involve wire work. This is simple and is made easy for small children to handle. Projects range from simple rings to a birds cage.

The theoretical work explains the use of different types of hammers, files, chisels, snips, vices, anvils, dividers, soldering iron, solders, punch, emery paper, rivet, etc.

In Class VII the project work is a little more advanced than in Class VI, and the theoretical work is related to the use of iron. The practical work involves hammering, grooving, polishing and painting.

Class VIII are given an introduction to measuring and lay out and to tools like the steel rule, scriber, hammer, face plate, divider, calipers, vice, anvil, centre punch. They are also introduced to the use of cutting tools like snip, hacksaw, drill and file. The processes they practice are layout, drawing, bending, soldering, snip cutting, chipping, filing, sawing, drilling, riveting, cleaning, polishing and brushing.

Pupils in Class VI who choose *applied electricity* begin the course with an introduction to the properties of a magnet and to the production of magnetic fields by various methods. They are then introduced to static electricity and to chemical electricity, the preparation of different liquid and dry cells, different type of wires and effect of current on them. Their work includes magnet making, the production of magnetic fields, the production of static electricity and observation of negative and positive charges, the preparation of electrolysis and the generation of chemical electricity, the making of different wire joints and of series and parallel circuits.

Class VIII are given an introduction to electricity and to ways of preventing accidents. They study different types of coils, different type of circuits and items used in electrical circuits such as switches, fuses, different types of circuits, one-way and two-way bulb control, the principles used in electric bell, and the circuit for tube lighting.

In their practical work, they prepare coil and magnetic fields, series and parallel circuits, different circuits to control single bulbs, two bulbs, etc. from one switch, they make an electric bell and the connections for tube lighting.

In Class VIII, pupils are introduced to different types of acids, to electrolysis, ionization, different types of fuses, and to Ohms law and numerical examples of its application. They encounter types of circuits, different units of measurement such as volts, amperes and ohms, different types of wire and ways of joining them, different meters and ways to read them. They meet also the electric generator and different electric appliances used in the home like heaters, irons and kettles.

Woodwork begins in Class VI with an introduction to simple hand tools such as the mallet, the steel rule, the try-square, the wooden vice scriber, the screwdriver, etc; then simple cutting tools like the jack and fine plane, the rip and cross cut saws, emery paper, etc. and, finally, finishing devices like paint, varnish, nail, brush, etc.

More detailed information is provided in Class VII along with kinds of nails, different types of artificial wood and their uses, joints of different types, different types of polishes their preparation and use. The pupils are also introduced to advanced cutting tools: saw, chisel, band drill, spoke shave and grinding wheel and to different skills like jointing, nailing, grooving, drilling, grinding (and its safety precautions), the use of wooden screwdriver, of plywood and pliers.

Class VIII undertake more difficult and skill oriented projects than Class VII and they learn more complicated skills like rounding off wood by a fine plane, making a square hole with the help of a chisel, rounding a surface with the help of a round file, making a hole with the help of slots, the introduction of lacquer work, rounding wood with the help of jack and file, the use of the chisel, of the grinding stone, plywood and its use. Finally, they learn about hinges and bolts the use of Raxin and of glue, and wax polish, the use of clamps and of the grinding stone.

Vocational education in secondary classes

This is available to students in the general group who can take one vocational subject offered by their schools. The vocational subjects are grouped under five categories: general, commercial, agricultural, industrial and home economics.

The suggested list of subjects under each group (proposed by the Ministry of Education) is called the 'Z' list. Each school is expected to offer subjects from one or more groups according to the developmental requirements of the area and its clientele. The 'Z' list is reproduced below.

The *General* group comprises six subjects, all of the same 'weight' so far as performance is rated in terms of marks awarded. These are education, health and physical education, elementary nursing and first aid, calligraphy, photography, and local (community) crafts.

The *Commercial* group is made up of eight subjects, but the first, typewriting, is compulsory. The remaining are book-keeping and accounts, secretarial practice, business methods, salesmanship, insurance, banking, and import and export procedure. Students are required to take one of these as well as typewriting. All seven are regarded as of equal 'weight'.

The *Agricultural* group includes seven subjects. The first of these, general agriculture, is compulsory. The remaining six are optional, but *two* must be chosen. The optional subjects are farm economics, crop production, livestock farming, animal production, productive insects and fish culture, and horticulture.

The *Industrial* group is very wide-ranging. It is sub-divided into eleven sub-groups which together make up a list of thirty-four different courses: any one of these thirty-four may be chosen, with a single exception: if a student elects to study a mechanical trade, he must take 'Fitting' in Class IX. Then, in Class X, he may continue the course in fitting or choose one of turning, plumbing, welding, electro-plating, or moulding and casting.

This requirement applies only to the sub-group of mechanical trades. The remaining twenty-eight optional courses fall under ten sub-headings as follows: the electrical trades group (electrical wiring, electrical winding, household appliances, or radio servicing), the wood trades group (furniture and cabinet making, wood carving and inlay work, joinery, or wood turning and lacquer work), the drafting trades group (mechanical drafting, or civil drafting), elementary printing or book binding, ceramics or glass-making, the building trades group (building trades - masonry, painting and distempering, or elementary surveying), the textile trades group (dyeing and drycleaning, plain weaving and laundry, or carpet weaving), the auto trades group (auto servicing, denting and spray painting, auto electricity, or agricultural implements repairing), the refrigeration and air conditioning trades group (refr ɜerator and air-conditioner servicing), the miscellaneous trades group (leather work, watch repairing, rubber and plastics, or gents tailoring).

The *home economics* group lists nine subjects, the first of which, principles of home economics, is compulsory. The optional subjects are related art, hand and machine embroidery, drafting and garment making, hand and machine knitting and crocheting, stuffed toys and doll making, preservation of fruits, vegetables and other foods, care and guidance of children, household management.

To integrate vocational subjects with the general curricula required the provision of workshops and technical teachers in all the secondary schools of the country, an enormous outlay, quite beyond the resources of Provincial Governments. It was therefore decided that the Federal Government would assist Provincial Governments to provide the facilities in all schools, and that until that time, vocational subjects would not form part of public examinations. At present, Agro-tech facilities are available in 4,843 schools, while vocational subjects are available in about 200. The progressive introduction of vocational subjects has, apart from financial difficulties, been slow for many reasons. Some of the major constraints are enumerated in what follows. The scheme of studies is now being revised in the light of the past ten years of experience.

THE POLICY OF THE MINISTRY OF EDUCATION ON THE PLACE OF TECHNOLOGY EDUCATION IN PRIMARY AND SECONDARY SCHOOLS

Agro-tech education was first introduced at the middle level in 1974 following the education policy of the period 1972-80. To begin with, instructional facilities were provided in about 1,200 middle schools at a cost of about US$ 10 million. Later, in 1976, the scheme was extended to cover secondary schools. The strategy of 'learning by doing' governs the teaching of technical education. The current policy on the provision of Agro-tech education in general education derives from a number of considerations and evident facts.

The expansion of science and technical education will result in the progressive integration of general and technical education in secondary schools and colleges. In the past, the general tendency was to establish separate institutions for technical education. These institutions have not always produced efficient industrial workers. The education given in them lacked a necessary cultural content, and, in practice, they catered for the rejects of the general stream, and a certain stigma was attached to their programmes. The new programme will provide for progressive integration of general and technical education.

At present, 60 to 70 per cent of students in secondary schools and general colleges are enrolled in arts subjects. There will be a massive shift from enrolment in arts towards enrolment in science and technical subjects and from an aimless general education to a more purposeful agro-technical education. To this end, the enrolment in arts subjects will be maintained at more or less the present level while significant increases

will be made in all high schools and general colleges in the provision of facilities for science and technical education. By 1990, one third of the total enrolment will be in each of the three main streams, arts, science and technical/occupational subjects. This will mean an increase in enrolment in technical subjects from the present 5 per cent to 33 per cent and in science subjects from 23 per cent to 30 per cent by 1990.

For science teaching, 2,200 additional units at the matriculation stage and 700 units at the intermediate stage will be established. Each unit will have facilities for 80 students at the rate of 40 in each class and will consist of two classrooms and a science laboratory. The additional places for teaching science to be created during the period come to 175,000 at the high stage and 56,000 at the intermediate stage.

Additional places will be created for technical/occupational students by establishing 3,500 additional units at the matriculation stage and 1,600 units at the intermediate stage for the teaching of these subjects. Each unit will have facilities for 80 students at the rate of 40 in each class. It will consist of 2 classrooms and a workshop.

The integration of general and technical education will equip secondary and college students for gainful employment, (including self-employment) in industry, agriculture, business, home economics and education in addition to providing for them a programme of general education. The areas of vocational occupational studies for which facilities will be developed include: electronics, auto-electricity, plumbing, household electrical appliances, dairy farming, poultry farming, vegetable farming, sericulture, crop and livestock production, shorthand, typewriting, insurance and estate broking, clearing, forwarding and shipping practices, home management, cooking and baking, first aid and home-nursing, food production and preservation.

Very determined efforts are being made to implement the Agro-tech scheme. Six Agro-tech teachers' training centres have been established to train teachers, and it is intended to strengthen these at a cost of Rs. 3 million. The curricula in Agro-tech subjects have been revised and some new technologies have been included in the package.

During the 6th Five Year Plan (1983-88), Rs. 90 million were spent on improving Agro-tech facilities in 3,000 middle schools, Rs. 32 million were spent on strengthening Agro-tech facilities in 200 high schools, Rs. 100 million were spent on establishing evening shift technical middle schools in general schools, and Rs. 38 million were spent on establishing 77 technical high schools as evening shift in general schools.

Better pay scales and more incentives have been provided to attract Agro-tech teachers, the curriculum for the pre-service training of Agro-tech teachers has been revised and training courses for the in-service training of Agro-tech teachers are being organized.